

UNITED STATES PATENT APPLICATION

WOOD COMPOSITE PANEL

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WOOD COMPOSITE PANEL

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Technical Field

This relates to decorative panels used in window and door units and in particular to a wood composite panel having increased resistance to movement due to moisture penetration and humidity changes.

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Background

Many of the current raised panels used in doors and in decorative windows provide inadequate resistance to moisture penetration. Ambient moisture caused by humidity and precipitation collects between the panel and the glazing cap, which holds the panel within the door. In some instances, moisture penetrates the panel and causes 15 swelling of the panel. Expansion of the panel through swelling can bow the panel and even force the panel out of engagement with the stiles and rails of the door.

Additionally, swelling and contraction of the panel causes undesirable cracking of the panel including the veneer and decreases the aesthetic appeal of a door. Moreover, cracking of the veneer allows additional moisture into the panel that causes increased 20 swelling and cracking. Further, the moisture that collects between the glazing cap and the panel also may damage the stiles and rails of the door, eventually requiring replacement of the entire door. Further still, because the panel swells, it is difficult to seal the panel within the frame to protect against moisture. As the panel swells within the frame, the panel shears the sealant.

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Many door assemblies and decorative windows use solid wood raised panels. Wood is porous and moisture (e.g. precipitation or humidity) easily penetrates the solid wood panels causing swelling and cracking. Varnish and staining treatments are sometimes applied to the outward facing surfaces of the raised panel after assembly of the door to protect against moisture. Typically, the edges of solid wood panels are 30 covered by the glazing cap during assembly. One disadvantage of this method of manufacture is that the panel edges are not varnished or stained because they are covered by the glazing cap. As moisture collects between the glazing cap and the panel

it penetrates the panel through the edges to cause swelling. Another disadvantage of this type of door is the extra manufacturing step necessary to stain or varnish the door. Additionally, the solid wood panel is susceptible to undesirable swelling and contraction caused by humidity changes.

5 Another type of door assembly uses a composite construction including wood strands or laminates. Flat wooden strands are saturated with resin and adhered together to form a substrate. A flat veneer is applied over the substrate to provide an appealing exterior. The relatively large size of the wooden strands (e.g. up to 20 inches long and 3 inches wide) provides for a rough outer substrate surface. One disadvantage of using a
10 wood strand or laminate substrate is the rough surface deforms thin pliable veneers used to provide profiled decorative surfaces. The rough surface presses through the pliable veneer causing undesirable surface texturing. Moreover, thicker veneers are less pliable and crack when pressed onto a profiled substrate used to form raised panels.

What is needed is a composite panel that overcomes the shortcomings of
15 previous panels. What is further needed is a composite panel that overcomes swelling due to moisture penetration and humidity changes, and provides a smooth profiled substrate for pliable veneer application.

Summary

20 A composite panel includes a fiberboard substrate including wood fiber and a waterproof resin. The panel includes at least one veneer disposed over a first face of the fiberboard substrate. In one example, a second veneer is disposed over a second face of the fiberboard substrate. A waterproof adhesive is disposed between the at least one veneer and the fiberboard substrate.

25 Several options for the composite panel follow. In one option, the first face of the fiberboard substrate has a profiled surface. In another option, the at least one veneer is pliable and assumes a profile corresponding to the profiled surface of the fiberboard substrate when disposed over the fiberboard substrate. In yet another option, the waterproof resin includes phenol formaldehyde. In still another option, the
30 waterproof resin includes methyl di-isocyanate. Optionally, the waterproof adhesive

includes cyanuramide. In another option, the waterproof adhesive includes polyurethane. In still another option, the waterproof adhesive includes urethane.

A door assembly includes a door having at least one panel cavity. In one option, an insulation core is disposed within the at least one panel cavity. At least one panel is disposed within the at least one panel cavity and coupled to the door. The at least one panel comprises a fiberboard substrate including wood fiber and a waterproof resin and having at least one profiled face. The at least one panel further includes a first veneer coupled to the at least one profiled face with a waterproof adhesive. In one option, the first veneer has a profile corresponding to the at least one profiled face of the fiberboard substrate. In another option, the at least one panel includes a second veneer, wherein the second veneer is coupled to another face of the fiberboard substrate with the waterproof adhesive, and the second veneer is substantially adjacent to the insulation core.

Several options for the door assembly follow. In one option, door assembly includes a glazing cap coupled to the door and engaged against the at least one panel to retain the at least one panel within the at least one panel cavity. In another option, a sealant is disposed between the at least one panel and the glazing cap. In still another option, the second veneer is slidably coupled to the insulation core, and the second veneer, fiberboard substrate and first veneer are moveable relative to the insulation core. Optionally, the door assembly includes a second panel having a second fiberboard substrate including wood fiber and waterproof resin, wherein a third veneer is coupled along at least one surface to a face of the second fiberboard substrate, and a fourth veneer is coupled along at least one surface to another face of the second fiberboard substrate and the fourth veneer is substantially adjacent to the insulation core. In one option, at least one bracket is coupled to the at least one panel and to the second panel. In another option, at least one glass pane is disposed within the insulation core and the at least one panel.

A method of making a panel includes compressing a fiberboard substrate including wood fiber and a waterproof resin, wherein the fiberboard substrate includes at least one face. A waterproof adhesive is applied to at least one surface of a first veneer. At least one surface of the first veneer is coupled to the at least one face of the

fiberboard substrate. In one example, the waterproof adhesive is applied to at least one surface of a second veneer. Optionally, the at least one surface of the second veneer is coupled to another face of the fiberboard substrate.

Several options for the method follow. In one option, applying the waterproof adhesive to the at least one surface of the veneer includes applying an adhesive including cyanuramide. In another option, the waterproof adhesive includes urethane. In still another option, the at least one face of the fiberboard substrate is milled to provide at least one profiled face. Optionally, the first veneer is pliable and assumes a profile substantially corresponding to the at least one profiled face when pressed against the at least one face of the fiberboard substrate.

The decorative panel disclosed herein is subject to less overall movement and decay relative to other panels. The combination of wood fiber and waterproof resin used in the substrate and the waterproof adhesive between the substrate and the veneer substantially prevents penetration of water into the panel, a cause of undesirable expansion, cracking and decay. Additionally, the substrate materials and the waterproof adhesive lessen expansive and contractive movement of the panel due to humidity changes. Further the small size of the wood fibers used in the substrate provides a smooth surface for application of a veneer. Pliable veneers applied over a profiled substrate using the materials and techniques described herein, assume the profile of the substrate. Because the substrate is smooth the pliable material does not have an undesirable texture caused with rough substrates. Moreover, in another example, because the panel is subject to less expansion, sealants are successfully applied between the panel and the glazing cap to aid in preventing water leakage. Moisture is less likely to collect between the panel and the stiles and rails of the door assembly and damage the door. Further, the decorative panel provides a long lasting appealing finish due to its resistance to movement, thereby reducing maintenance concerns.

The composite panel disclosed herein comes preinstalled in door assemblies and decorative windows. In another option, the composite panel is useful as a replacement panel for existing doors and decorative windows. In yet another option, the composite panel is useful for indoor and outdoor applications.

These and other embodiments, aspects, advantages, and features of the present invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art by reference to the following description of the invention and referenced drawings or by practice of the invention. The aspects, 5 advantages, and features of the invention are realized and attained by means of the instrumentalities, procedures, and combinations particularly pointed out in the appended claims and their equivalents.

Brief Description of the Drawings

10 Figure 1 is a front view illustrating a composite panel constructed in accordance with one embodiment.

Figure 2 is a cross-sectional view illustrating a composite panel constructed in accordance with one embodiment.

15 Figure 3 is a cross-sectional view illustrating a panel assembly constructed in accordance with another embodiment.

Figure 4 is a cross-sectional view illustrating a panel assembly constructed in accordance with yet another embodiment.

Figure 5 is a cross-sectional view illustrating a panel assembly constructed in accordance with still another embodiment.

20 Figure 6 is a block diagram illustrating a method for making a composite panel.

Figure 7 is a front view illustrating a door assembly constructed in accordance with one embodiment.

Figure 8 is a front view illustrating a door assembly constructed in accordance with another embodiment.

25 Figure 9 is a cross-sectional view illustrating a door assembly constructed in accordance with one embodiment.

Figure 10 is a block diagram illustrating a method for making a door assembly.

Description of the Embodiments

In the following detailed description, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural changes may be made without departing from the scope of the present invention. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims and their equivalents.

Figure 1 is a front view of a composite panel 100 for use in a door assembly or decorative window assembly. In one example, the composite panel includes a profiled face 102. In one option, the profiled face 102 is convex and the center portion 104 of the face 102 forms the upper surface of the profiled face 102. In another option, a skirt 106 surrounds the center portion 104 and the slopes 108. The slopes 108 extend between the skirt 106 and the center portion 104. In yet another option, the center portion 104 of the profiled face 102 is concave and forms a lower surface of the profiled face 102. Optionally, the profiled face 102 of the composite panel 100 includes multiple convex and/or concave portions.

Figure 2 is a cross-sectional view of the composite panel 100 showing a first veneer 200 and a second veneer 202 coupled to a fiberboard substrate 204. In one example, the fiberboard substrate 204 includes a first face 208 and a second face 210. In one option, the first face 208 is profiled. In another option, the second face 210 has a substantially planar geometry. In another example, the first veneer 200 and second veneer 202 are adhered to the first face 208 and the second face 210, respectively with a waterproof adhesive 206. In yet another example, at least the first veneer 200 is pliable, and when adhered to the first face 208 of the fiberboard substrate, the first veneer 200 wraps around the profile of the first face 208. The pliable first veneer 200 wraps around the profile of the first face 208 without cracking. The first veneer 200 has a thickness between about 0.005 inches to 0.04 inches to make the first veneer 200 pliable and able to assume the profile and avoid cracking. When coupled to the

fiberboard substrate 204, the first veneer 200 provides the profiled face 102 of the composite panel 100 by assuming the profile of the first face 208. In one example, the first veneer 200 and the second veneer are around 0.02 inches thick. In another example, the first veneer 200 and second veneer 202 include wood. Generally, a 5 variety of woods are useable in the first veneer 200 and the second veneer 202 because of the low coefficient of expansion of the substrate 204. The low coefficient of expansion aids in preventing shearing of the waterproof adhesive 206 between the veneer 200, 202 and the fiberboard substrate 204. In another example, the wood in the first veneer 200 and second veneer 202 is varnished, stained or the like. In yet another 10 example, the first veneer 200 and second veneer 202 are prepainted.

In one option, the waterproof adhesive 206 used to couple the first veneer 200 and the second veneer 202 to the fiberboard substrate 204 is a Type 1 rated waterproof adhesive.

The waterproof adhesive 206 includes but is not limited to cyanuramide, a compound 15 sold or distributed under the trademark MELAMINE™ registered to Melamine Chemicals, Inc. In another option, the waterproof adhesive includes urethane, polyurethane or the like. One example of a waterproof adhesive 206 is a glue having the trade name MUF 4301 made by National Casein, and including MELAMINE™. Another example of a waterproof adhesive 206 capable of being used alone or mixed 20 with an additional adhesive is WP 2200 made by National Casein. In one example, MUF 4301 waterproof adhesive is mixed with WP 2200 waterproof adhesive at about a 95% to 5% volume ratio, respectively.

The fiberboard substrate 204 of the composite panel 100 includes wood fibers and a waterproof resin. In one example, the fiberboard substrate 204 is constructed 25 with wood fibers created in a fiberizing process that pulls wood apart into fibers. In one option, fiberizing generates wood fibers having a range of lengths between about 0.5 to 8 millimeters. In another option, the wood fibers are the length of one or four cells. The wood fibers used in fiberboard substrate 204 include but are not limited to soft wood fibers, hard wood fibers, or a mixture of soft wood and hard wood fibers.

30 The waterproof resin used to bond the wood fibers together, in one example, is a phenolic resin (e.g. phenol formaldehyde or the like). In another example, the

waterproof resin includes methyl di-isocyanate. In one option, the waterproof resin is sprayed on the wood fibers and the mixture of wood fiber and waterproof resin is tumbled to evenly distribute the resin among the fibers. The mixture is then compressed into a board. Optionally, the mixture of wood fiber and waterproof resin is 5 heated during compression.

In one example, the fiberboard substrate 204 has a density of between about 45 lbs./ft³ to 80 lbs./ ft³. In another example, the fiberboard substrate 204 has a lineal expansion of about 0.58 % in 50 % to 90 % relative humidity, where the substrate 204 has a thickness between about 0.375 inches and 1.5 inches. Application of the 10 waterproof resin to the wood fibers binds the wood fibers together to create the fiberboard substrate 204. In one example, the waterproof resin provides at least some measure of waterproofing to the fiberboard substrate 204. In another example, the waterproof resin and the waterproof adhesive 206 cooperate to make the composite panel 100 substantially waterproof. Optionally, the combination of the waterproof 15 adhesive and the waterproof resin substantially prevents penetration by moisture (e.g. precipitation or humidity) into the composite panel 100. In another option, the mixture of the wood fibers and the waterproof resin makes the fiberboard substrate 204 resistant to expansive and contractive movement caused by humidity changes.

Figure 3 is a cross-sectional view of a panel assembly 300 including two 20 composite panels 100. In one example, the panel assembly 300 includes an insulation core 302. In one option, the insulation core 302 includes foamed polystyrene, or the like. One example of polystyrene suitable for the insulation core 302 is a material sold under the trademark STYROFOAM™ and registered to the Dow Chemical Company. In another example, the second veneers 202 of the composite panels 100 have a 25 corresponding surface area to the sides of the insulation core 302. In yet another example, the second veneers 202 are substantially adjacent to the sides of the insulation core 302. Optionally, the second veneers 202 are slidably coupled to the sides of the insulation core 302. In another option, the composite panels 100 (fiberboard substrates 204, first veneers 200 and second veneers 202) are moveably 30 coupled through the second veneers 202 to the insulation core 302. In yet another example, the two composite panels 100 are constructed with the same materials. In

one option, the two composite panels 100 include different materials or different ratios of materials in the fiberboard substrates 204. In another option, the composite panels 100 include different first veneers 200 and/or second veneers 202. The composite panels 100 include different profiled faces 102, in another example.

5 Figure 4 is a cross-sectional view of another example of a panel assembly 400 including two composite panels 100 and an insulation core 302. In one example, the composite panels 100 and the insulation core 302 include a glass cavity defined by the inner surfaces 403 of the composite panels 100 and the insulation core 302. The panels 100 and insulation core 302, in one option, are dimensioned and configured to retain a
10 glass pane 404 therein. In another option, at least one bracket 406 is coupled to the composite panels 100 and spans the insulation core 302. The at least one bracket 406 has a substantially planar geometry, in yet another option. The at least one bracket 406 includes but is not limited to aluminum, steel or the like. In another example, the at least one bracket 406 maintains the spacing between the composite panels 100. In one
15 option, fasteners such as screws 408 or the like are driven into the inner surfaces 403 of the composite panels 100 to couple the at least one bracket 406 to the panels 100. Optionally, the at least one bracket 406 is coupled to the composite panels 100 with adhesives, nails or the like. The glass pane 404 engages the at least one bracket 406, in yet another example, when disposed within the glass cavity defined by the inner
20 surfaces 403. The glass pane 404 is secured within the composite panels 100 and insulation core 302, in one example, with beads 407. The beads 407 are coupled to the composite panels 100 with nails, screws or the like.

25 Figure 5 is a cross-sectional view of still another example of a panel assembly 500 including two composite panels 100 and an insulation core 302. In some respects, panel assembly 500 is similar to panel assembly 400. As described above, the composite panels 100 and insulation core 302 are dimensioned and configured to retain a glass pane 404 within a glass cavity defined by the inner surfaces 403. At least one bracket 506 is coupled to the composite panels 100, in one option. Optionally, the at least one bracket 506 has an "L" shaped geometry. In one example, fasteners such as screws 408 or the like are driven into the composite panels 100 to couple the at least one bracket 506 to the panels 100. In another example, the glass pane 404 engages the
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at least one bracket 506 when disposed within the glass cavity. The glass pane 404 engages the at least one bracket 506 and the inner surface 403 of the composite panel 100, in still another example. Optionally, the fiberboard substrate 204 of the composite panel 100 is more deformable than the at least one bracket 506. In another 5 option, the fiberboard substrate 204 absorbs pressure between the composite panel 100 and the glass pane 404 when the glass pane 404 is engaged against the inner surface 403 of the panel 100. The glass pane 404 is secured within the composite panels 100 and insulation core 302, in one example, with beads 407. The beads 407 are coupled to the composite panels 100 with nails, screws or the like.

10 Figure 6 is a block diagram showing a method 600 for making a composite panel. At 602, a fiberboard substrate including wood fiber and a waterproof resin is compressed. In one option, the method 600 includes milling the at least one face of the fiberboard substrate to provide at least one profiled face. At 604, a waterproof adhesive is applied to at least one surface of a first veneer. At 606, the at least one 15 surface of the first veneer is coupled to at least one face of the fiberboard substrate. Optionally, at least the first veneer is pliable and assumes a profile substantially corresponding to the at least one profiled face of the fiberboard substrate when the veneer is pressed against the at least one profiled face. In another example, the waterproof adhesive is applied to at least one surface of a second veneer. The at least 20 one surface of the second veneer is coupled to another face of the fiberboard substrate.

Several options for the method follow. In one option, the waterproof adhesive applied to the at least one surface of the veneer includes MELAMINE™. The waterproof adhesive includes urethane, in another option. Compressing of the fiberboard substrate includes heating the substrate, in still another option. In yet 25 another option, coupling the at least one surface of the veneer to the at least one face of the fiberboard substrate includes heating the waterproof adhesive.

Figure 7 is a front view of a door assembly 700. Door assembly 700 includes composite panels 702A, B, C, D, E. In one option, corresponding panels are included on the opposite side of the door assembly 700. Optionally, the panels 702A, B, C, D, E 30 and corresponding panels are included in panel assemblies including an insulation core, described above. The panels 702A, B, C, D, E include similar materials, in

another option. The geometry of panels 702A, B, C, D, E are varied, in yet another option, to provide different sizes and shapes of panels. In one example, panels 702A, B, C, D, E have differing profiles to provide different decorative appearances for the panels.

5 The door assembly 700 includes a door 701 having stiles 704A, B, C, D and rails 706A, B, C, D. In one example, the door assembly 700, including stiles 704A, B, C, D and rails 706A, B, C, D is constructed from wood. The stiles 704A, B, C, D and rails 706A, B, C, D include aluminum, steel, or the like, in another example. In yet another example, the stiles 704A, B, C, D and rails 706A, B, C, D are constructed with 10 composite materials, for example, laminated wood strands, wood fibers, or the like. Optionally, the door 701 includes a handle 708, for example a door knob. The door assembly 700 includes a frame for installation of the door assembly 700 within a surface (e.g. a wall), in another option.

Figure 8 is a front view of door assembly 800. In one example, door assembly 15 800 includes at least one glass pane 802 disposed within a door 801. The door assembly 800 includes multiple glass panes 802, in another example. In yet another example, the glass pane 802 is coupled to a panel 804 including a fiberboard substrate, waterproof adhesive and at least one veneer. Optionally, the glass pane 802 is coupled to the panel 804 and a corresponding panel on the opposite side of the door 801. A 20 panel assembly, similar to panel assembly 400 (Figure 4), includes the glass pane 802 disposed within the panels 804 and an insulation core, in another option.

Figure 9 is a cross-sectional view of a door assembly 900 including panel assembly 300. In one example, panel assembly 300 is retained within a panel cavity of the door assembly 900 dimensioned and configured to house the panel assembly 25 300. As shown in Figure 9, the panel assembly 300 is retained between stiles 901. In another option, the panel assembly 300 is retained between stiles 901 and/or rails of a door. The panel assembly 300 is retained within the door assembly 900 with glazing caps 902, in another example. In one option, the glazing cap 902 includes a deformable seat 904. In another option, the deformable seat 904 includes vinyl, rubber 30 or the like. The deformable seat 904 includes a tongue 906 dimensioned and configured to interference fit within a kerf 908 of the stile 901, in yet another option.

The tongue 906 includes at least one ridge 910. The at least one ridge 910 is dimensioned and configured to engage a surface of the kerf 908. Optionally, engagement of the at least one ridge 910 applies a torsional force to the deformable seat 904, forcing a retaining lip 912 to engage against the panel assembly 300. In one 5 option, the retaining lip 912 engages the first veneer 200. The retaining lip includes a deformable bead 913, in another option, to engage against the first veneer 200. In yet another option, the retaining lip 912 and an opposing surface 914 of the stile 901 retain the panel assembly 300 within the door assembly 900. A sealant 915 (e.g. silicone) is applied to retaining lip 912, in still another option. The sealant 915 creates a seal 10 between the glazing cap 902 and the panel assembly 300 to substantially prevent moisture penetration between the panel assembly 300 and the stiles 901 and/or rails of the door assembly 900. In another example, the glazing cap 902 includes a decorative trim 916 coupled to the deformable seat 902. In one option, the deformable seat 902 includes a vinyl barb 918 dimensioned and configured to interference fit within a kerf 15 920 of the deformable seat 902. The decorative trim includes but is not limited to wood, wood composite, or the like. In another example, panel assembly 300 is retained within the door assembly 900 with glazing beads. Glazing beads are engaged to the panel assembly 300, in one option, and nails or the like are driven through the glazing beads to retain the panel assembly 300 and glazing bead within the door 20 assembly 900.

In yet another example, a panel assembly including an insulation core 302 and one panel 100 is retained within a clad door assembly. The clad door assembly is similar to the door assemblies described above in some respects. The clad door assembly includes a second panel integral to the clad door. In one option, the clad 25 door including the second panel is constructed to include aluminum, steel or the like. The insulation core 302 is disposed within the clad door so it engages the integral second panel. The panel 100 is then inserted into the clad door against the insulation core 302 and a glazing cap 902 or the like is used to retain the panel assembly within the door.

30 Figure 10 is a block diagram illustrating a method 1000 for making a door assembly. At 1002, a door is provided including at least one panel cavity dimensioned

and configured to house at least one panel assembly. At 1004, an insulation core is disposed within the at least one panel cavity. At 1006, a first panel is disposed within the at least one panel cavity. The first panel includes a fiberboard substrate of wood fiber and a waterproof resin and a veneer coupled to the substrate with a waterproof adhesive. In one option, the first face of the insulation core is engaged against the first panel. At 1008, the first panel and the insulation core are retained within the at least one panel cavity. In one option, a second panel is disposed within the at least one panel cavity. The second panel includes a fiberboard substrate of wood fiber and the waterproof resin, in one example, and a veneer coupled to the substrate with the waterproof resin. Optionally, the method 1000 includes disposing at least one glass pane within at least one glass cavity in the first panel, the insulation core and the second panel. A bracket is coupled to the first panel and the second panel, in another option, along surfaces defining the at least one glass cavity of the first panel and the second panel.

Several options for the method 1000 follow. In one option, the first panel and the insulation core are retained within the at least one panel cavity by coupling a glazing cap to the door and engaging the glazing cap against the veneer of the first panel. In another option, the first panel and the insulation core are retained within the at least one panel cavity with a glazing bead coupled to the frame (e.g. with nails) and engaged against the veneer of the first panel. In yet another option, sealant is interposed between the glazing cap and the veneer of the first panel.

The decorative panel disclosed herein is subject to less overall movement and decay relative to other panels. The combination of wood fiber and waterproof resin used in the substrate and the waterproof adhesive between the substrate and the veneer substantially prevents penetration of water into the panel, the main cause of undesirable expansion, cracking and decay. Additionally, the substrate materials and the waterproof adhesive lessen expansive and contractive movement of the panel due to humidity changes. Further the small size of the wood fibers used in the substrate provides a smooth surface for application of a veneer. Pliable veneers applied over a profiled substrate using the materials and techniques described herein, assume the profile of the substrate. Because the substrate is smooth the pliable material does not have an

undesirable texture caused with rough substrates. Moreover, because the panel is subject to less expansion, in one example sealants are applied between the panel and the glazing cap to aid in preventing water leakage. Moisture is less likely to collect between the panel and the stiles and rails of the door and damage the door. Further, the 5 panel provides a long lasting appealing finish due to its resistance to movement, thereby reducing maintenance concerns.

The composite panel disclosed herein comes preinstalled in door assemblies and decorative windows. In another option, the composite panel is useful as a replacement panel for existing doors and decorative windows. In yet another option, the composite 10 panel is useful for indoor and outdoor applications.

It is to be understood that the above description is intended to be illustrative, and not restrictive. Many other embodiments will be apparent to those of skill in the art upon reading and understanding the above description. It should be noted that 15 embodiments discussed in different portions of the description or referred to in different drawings can be combined to form additional embodiments of the present application. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.